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WIND POWER TURBOGENERATOR FOR HIGH ALTITUDE WIND UTILIZATION

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WIND POWER TURBOGENERATOR FOR HIGH ALTITUDE WIND UTILIZATION

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Wind power machines with double-wheel turbines of large dimensions and significant capacities, which generate electricity directly in the elements of the vane connections, are known from descriptions and patents. Single-wheel turbines of very large dimensions are also known, which transfer the power collected through heavy gears to generators of known design. The three-phase voltage and frequency generated by these known large wind power machines fluctuate seriously because of the variability of the wind velocity. In parallel operation of these three-phase wind power machines with a power net, synchronization is made difficult because the rotational speed of the turbine, determined by the wind speed, is not controllable. Therefore, auxiliary equipment such as transformators, converters, controlled rectifiers, etc., are necessary. This introduces significant losses in power and increases in the system costs. Thus, three-phase /1*

* Numbers in the margin indicate pagination in original foreign text.

generation produces unreliability in operation. Descriptions of wind power plants also refer to the difficulties of regulating the speed of rotation. It is also emphasized there that the power transfer has likewise not yet been thought out sufficiently. Finally, it is established that there is not yet any successful voltage regulation.

The disadvantages of this known method, increase of the system cost by as much as doubling, power loss, questionable economy and limited applicability of the wind power plants in parallel operation with an adequately inflexible net or operating alone, are avoided by this invention.

The invention concerns wind power machines in the form of double wheel turbines which generate direct current directly in counter-rotating commutator machines which are subdivided, according to the invention, into controllable stages, and which supply regulated direct current or, after conversion, controlled three-phase current to the users.

According to the invention, collector machines of previously /2
unknown size up to 100 m diameter are used, in which the commutator and generator are in a relation which is acceptable for construction and economy.

It is possible to move through the interiors of these machines. The commutator and brushes are accessible during operation and are under continuous surveillance. The previously known generators had stators and rotors which differed because a rotating part, the rotor, moved with its axis in a fixed part, the stator. In contrast, with these machines, the stator and rotor counter-rotate about a fixed axis. According to the invention, however, they do not rotate about a shaft with massive cross section, but about a fixed truss structure with walls which are connected together and which carry rollers on which the hub rings of the generator parts rotate. It is possible to pass through this axis with a foot bridge, and from there out to other bridges between the turbine wheels to the two counter-rotating rings at the air gap. This makes it possible to monitor the commutator and brushes even in full operation. As the axis becomes slanted in tilted operation and the footboards of the footbridge tilt with it, according to the invention the structure of the footbridges should be tubular so that the service personnel can stay upright and follow the tilting movement.

The wind power machine, as a tilting turbine, is provided with mechanical power control in a manner which is in itself known. This, however, extends, according to the invention, to isolated operation, and so to the total range of the most frequent wind speeds between 3 and 15 m/s. This range is extended, in comparison to those for parallel operation of three-phase wind power machines, because the direct current machine, according to the invention, can also include the relatively frequent winds with speeds from 3 to 7 m/s.

The power changes with the third power of the wind speed. The rotational speed and voltage fluctuate, and change in the ratio of the wind speeds. Direct control of the voltage, in the ratio of the smallest to the largest wind velocity which can be used, in the ratio of 3 m/s : 15 m/s = 1:5, departs too greatly from the usual regulation in the ratio of 1:2.

According to the invention, therefore, the power is to be subdivided into steps and built up of steps with the same power. The existing generator capacity determines the number of steps. These steps are in the ratio of 1:2, so that they can be controlled without difficulty with respect to rate of rotation and voltage.

Up to a wind speed of 12 m/s, the generator and control equipment work in balanced continuous operation. Wind gusts from 12 to 15 m/s provide stresses over a time of a few minutes to several hours, according to accurately made measurements. In these periods the generators are temporarily overloaded under some circumstances.

The mechanical power control begins to operate at a wind speed of 15 m/s. At higher wind speeds it holds the power constant and prevents overloads.

For a large wind turbine with a useful area of, for example, 20,000 m^2, the generator powers, N_e, change approximately as follows as a function of the wind speed, v:

At v =	3	5	7	9	12	15	20	m/s
N_e =	100	500	1500	3200	8000	16000	16000	kW

According to the invention, these powers are broken up into steps of 400 kW each, which are automatically switched to follow the load, thus controlling the rotating speed and voltage, in the following number:

1	2	4	8	20	20	20

The control ratio 1:2 is maintained and therefore, according to the invention, regulation is assured. Parallel operation with a three-phase network can be carried out without additional equipment as a result of the control of rotational speed and voltage in the transformation. One particularly great advantage of the commutator wind power machine, according to the invention, is its greater, and therefore superior, yearly work in isolated operation. This superiority is even ensured if we admit a greater efficiency for synchronous three-phase parallel operation.

As is seen in the following comparison of the yearly works for wind power fields with quite different wind speeds and wind frequencies, a large work excess remains ensured for the commutator machines even with large differences.

An investigation of the annual works, based on accurate observations of the wind over many years in eight different wind power fields in the West, as a comparison for isolated operation according to the invention, as well as for network parallel operation, using the useful turbine area assumed as an example, yielded the following amounts of work provided annually, in millions of kilowatt hours. The efficiency was limited to η = 0.92 for isolated operation, but was increased to 0.93 for network operation.

Wind Power Field	Millions of kilowatt-hours					
	High Rhone	Wilhelms-haven	Berlin Lndnbg.	Bavarian Alps	Sauerland	North Sea
Isolated operation	34,3	42,2	42,2	44,4	60,6	63,3
Network operation	31,3	38,1	38,8	41,0	57,0	60,1
Extra power from network operation	3,0	4,1	3,4	3,4	3,6	3,2

	List Island	Brocken-Harz
Isolated operation	63,8	81,0
Network operation	60,8	78,8
Extra power from network operation	3,0	3,4

Utilization of the wind power according to the invention offers the following advantages: The commutator machine avoids additional costly installations which cause power losses. The synchronous three-phase network operation is simplified by conversion, which is matched in steps to the power available, and which can be regulated in acceptable ratio with respect to rotational speed and voltage. The annual work is higher, and the efficiency of the wind power plant is considerably improved at lower system cost. The wind power plants described in the invention can take on power supply individually as well as being used in connected operation. /3

Operation of a group of wind power plants can be simplified by having the converter group jointly controlled from one regulator.

While known generators are roller-shaped bodies placed inside cylindrical bodies, the direct current wind power machine of the invention consists of two wide wheels with large diameter, each with two walls made of spokes. These hold hubs bored out wide, with pressure and tension-resistant rings, from which the wheel spokes go out, carrying strong rings as wheel tires. The internal rings carry the armature with the brush guides, so that the brushes are concentric at the inside and are easily accessible from the foot-bridges. The vanes of the turbine wheel, which twist into the feathered position under the force of the wind are supported on the double wheel system of the generator so that compressive forces arise which elastically shorten the tires which make up the ring system with the pole yokes. The play of forces is reversed in the ring system of the second wheel, which is concentrically outside at the air gap. The outer ring would expand under the influence of the static forces. The result would be a widening of the air gap, which would necessarily also affect the reliability of the brush guides. This is prevented, according to the invention, by the internal position of the yoke ring with the brush carriers. Simultaneously with the static forces, magnetic forces also arise at the air gap. With the great generator power, these are considerable. These forces, acting in the radial direction, load the internal ring system with the pole yoke ring in tension and attempt to expand the whole ring. The ring system lying concentrically at the outside is contracted under compression.

Therefore, the elastic motions in the rings at the air gap are counteracted for both types of stress. They mutually eliminate each other almost completely, and the motions at the air gap remain small. The brushes are led to the commutator at a secure position.

The exciter current for the armature coils is fed from the fixed axis out to the armature wheel through slip rings, which are in themselves well known. The direct current which is generated is not taken off at the armature wheel, but through slip rings which are also installed concentrically between the hub rings of the armature wheel.

In parallel operation with a three-phase network, the wind power plant as described in the invention is not directly affected by the net frequency. Only the three-phase power side of the individual converter stages is frequency-dependent. The rotating speeds of the wind power plant are not limited and its rotating masses can experience brief strong wind gusts without hindrance. The rotating speed and voltage fluctuations from short gusts are limited and the balance between the stages is simplified.

PATENT CLAIMS

1. Wind power turbogenerator for utilization of high altitude wind, characterized by the fact that counter-rotating turbine wheels carry the poles and brushes between the vanes on one wheel, and the armature and commutator on the other wheel.

2. Wind power turbogenerator according to Claim 1, characterized by the counterrotating wheels with the commutators and brush carriers rotating about a fixed axis.

3. Wind power turbogenerator according to Claims 1 and 2, characterized by the fact that the pole wheel with the brush carriers is built as an inner ring concentric inside the armature wheel.

4. Wind power turbogenerator according to Claims 1 to 3, characterized by the fact that the pole coils with the exciting power input and the slip rings for the power takeoff are provided on the pole wheel.

5. Wind power turbogenerator according to Claims 1 to 4, characterized by the fact that the commutator support rings are connected to the hub rings of the armature wheel.

6. Wind power turbogenerator according to Claims 1 to 5, characterized by the fact that the fixed axis is provided with passages leading to the brushes and commutator.

7. Wind power turbogenerator according to Claims 1 to 6, characterized by the fact that the passages are of metal and have a tubular cross section.

8. Wind power plant for utilization of high altitude wind with wind power turbogenerator according to Claims 1 to 7, characterized by the fact that power production is in stages which are controlled for constant rotational speed.

9. Wind power plant according to Claim 8, characterized by the fact that that the powers from the stages are summed through controllable converters of the same power.

10. Wind power plant according to Claims 8 and 9, characterized by the fact that the synchronization for parallel operation with a three-phase network is carried out on the direct-current side from the generator.

11. Wind power plant according to Claims 8 to 10, characterized by the fact that the total power is subdivided into controllable power stages. /4

12. Wind power turbogenerator according to Claims 1 to 7, characterized by the fact that it is designed for combined operation as well as being a machine for isolated operation.

Publications cited:
ETZ 59(1938), pages 1373 and following, and 1404 and following.

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16. Abstract

German patent describes a wind-powered electrical generator consisting of two counter-rotating wheels, one being the armature and the other being the field. Means of compensating for varying wind speed are described.

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